Concentrate Supplements for Weanling and Finishing Steers

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Concentrate Supplements for Weanling and Finishing Steers

Author

M.G. Keane

Teagasc, Grange Research Centre, Dunsany, Co. Meath

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Dunsany
Co. Meath

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SUMMARY

Concentrates are a major cost element in feeding beef cattle in winter. Because of the need to retain finishing cattle until after specific dates to comply with retention periods for the draw-down of premia, feeding strategies must be flexible. The objectives of this study were to examine concentrate feeding strategies which would minimise concentrate feeding to weanlings and exploit compensatory growth, simplify feeding routines and improve the efficiency of concentrate utilisation in finishing cattle. Four experiments were carried out, two with weanlings and two with finishing cattle.

- Weanlings fed outdoors (in sacrifice paddocks) in winter gained 13 kg more than those similarly fed indoors but by the end of the following grazing season the weight difference had decreased to 4 kg as a result of compensatory growth.
- There was no response to an increase in protein level in the concentrate.
- Feeding 2 kg/day of supplementary concentrates with silage in winter reduced silage intake by 0.4 kg dry matter (DM) and increased total DM intake by 1.27 kg/day.
- The liveweight gain response in winter to 2 kg/day supplementary concentrates was 344 g/day or a total of 44 kg. By the end of the following grazing season this had declined to 14 kg (68% compensation)
- The conversion ratio of concentrate DM to liveweight was about 5:1 at the end of winter but by the end of the following grazing season it was over 15 : 1.
- Feeding a fixed total concentrate allowance to weanlings gave a better response when it was offered at a flat rate daily over the whole winter, or at a high rate over the first half of the winter, rather than when offered at a high rate over the second half of the winter.
- Feeding a fixed total concentrate allowance *ad libitum* over the final part of the finishing period was superior to feeding it at a flat rate per day over the total period in terms of feed energy utilization.
- There was no impairment in the efficiency of total feed energy utilization by delaying the feeding of a fixed concentrate allowance for up to 70 days after housing compared to feeding it immediately after housing.

- Where animals are being finished over a 5-6 months period, rather than feeding concentrates at a flat rate throughout the whole period, it is better to delay introduction for 2-3 months and then offer concentrates *ad libitum* thereafter.
- As the interval from housing to concentrate introduction increases, the response to concentrates fed *ad libitum* subsequently increases.
- Although not reflected in carcass fat score, objective indicators of fatness were lower for animals fed concentrates *ad libitum* than for animals fed concentrates at a flat rate with silage.

INTRODUCTION

Concentrates are a major cost element in feeding beef cattle in winter, particularly finishing cattle, and because of the need to take account of premia dates and retention periods to optimise the draw-down of premia, feeding strategies must be flexible. There are two main categories of beef cattle to be fed in winter :

i. Weanlings animals entering their first winter and which are at least a year from slaughter

ii. Finishers - animals being finished for slaughter over the winter.

From a feeding view point, the main difference between the two types is that weanlings have time after the winter to exhibit compensatory growth whereas the finishers do not. However, weanlings are still immature and relatively underdeveloped so a minimum rate of gain is necessary to ensure essential bone and muscle growth. For dairy calf-to-beef production systems this minimum has been set at about 0.5 kg/day (Keane, 2001).

Unlike weanlings which have the time subsequently to compensate for low performance in winter, finishers are slaughtered at the end of winter and differences in winter performance are reflected directly in slaughter weight, carcass weight and carcass value. In addition to carcass value, draw-down of premia must also be considered, and in two-year-old systems payment of the second Special Beef Premium (SBP) is generally at around slaughter time so it is not economically sensible to finish and slaughter animals before drawing the second SBP. This can sometimes involve retaining animals beyond the normal level of finish or delaying or slowing finishing to ensure the animals are eligible for premia. The objective of this study was to examine concentrate feeding strategies which would simplify the feeding routine, improve the response to concentrates or permit a delay in slaughter (to ensure collection of premia for example) without impairing the efficiency of concentrate utilization. In total, four experiments were carried out, two with weanlings and two with finishing cattle.

WEANLINGS

Experiment 1

Response to Concentrates and Protein Outdoors and Indoors.

Introduction

With the declining profitability of beef production, cattle may in future have to be managed outdoors on low cost rations in winter. This may necessitate the use of sacrifice paddocks or construction of stand-off-pads. Because of the increasing cost of protein supplements and the growing awareness of nitrate pollution of ground water, protein levels in ruminant diets need to be examined more critically.

The objectives were (1) to compare the performance of weanlings fed outdoors and indoors in winter, (2) to determine the response to supplementary concentrates when silage was offered *ad libitum* , and (3) to determine the response to an increase in the protein concentration of the concentrate.

Experimental

Seventy spring-born Charolais x Friesian weanling steers, 8 - 9 months old and 218 kg initial liveweight, were used. They were at pasture from early May until November 12 when they were blocked on weight and assigned to 5 treatment groups as follows:

1) Silage only outdoors
2) Silage + 2 kg concentrates (low protein) per head daily outdoors
3) Silage only indoors
4) Silage + 2 kg concentrates (low protein) per head daily indoors
5) Silage + 2 kg concentrates (high protein) per head daily indoors.

The outdoor animals were assigned a total pasture area of 0.1 ha per animal for the winter. This was divided into 3 paddocks which were used successively from November 12 to December 22, December 23 to January 22 and January 23 to March 19. The silage and concentrates were offered in troughs on a hardcore area (part of a handling yard) to which the animals had access from their paddocks via passageways.

Before the experiment commenced the outdoor pasture area was grazed to a stubble height of 6 cm so that any contribution of pasture to the diet of the animals would be minimal. The indoor treatment groups were accommodated in a slatted floor shed. Silage intake was measured on 4 days per week on a group basis and concentrates were fed once daily. The silage analysis was (g/kg) : dry matter (DM) 171, pH 4.1, crude protein (CP) in the DM 174, and *in vitro* DM digestibility (DMD) 728. The concentrate formulation was (g/kg) : barley 933, molasses 47, minerals/vitamins 20 (low protein), and barley 793, soyabean meal 140, molasses 47 and minerals/vitamins 20 (high protein). The chemical analysis of the concentrates was (g/kg) : DM 856, CP 120, ash 41, crude fibre (CF) 34 (low protein), and DM 865, CP 159, ash 40 and CF 38 (high protein). The duration of the treatments was 127 days after which all the animals were put to pasture together for a 218-day grazing season.

The data were analysed as a 2 (outdoor and indoor environments) x 2 (concentrate levels) factorial design using Treatments 1, 2, 3 and 4. Then the two protein levels were contrasted. The data are presented as treatment means with the significance of the main effects, their interaction and the protein effect indicated.

Results

Silage DM intake was slightly higher (4.22 v. 4.10 kg/day) indoors than outdoors (Table 1). This may reflect a small contribution by pasture to the diet of the outdoor animals. Feeding 2 kg concentrates per day reduced silage intake by 0.44 kg/day (4.38 v. 3.94 kg/day). Thus, concentrate supplementation increased total DM intake by 1.27 kg/day giving total DM intakes of 4.38 and 5.65 kg/day for the silage only and silage plus concentrate treatments, respectively. Compared with the low protein concentrate, the high protein concentrate increased protein intake by about 80 g/day.

Lightweight gains are also shown in Table 1. Over the first 55 days there was no significant effect of environment although there was an interaction involving environment indicating that the response to concentrates was less outdoors than indoors. This might be due to pasture making some contribution to the diet of the animals fed silage only outdoors. Over the period from 55 days to end of winter, the outdoor animals gained significantly faster than those indoors (798 v. 640 g/day). For the winter period as a whole the outdoor animals gained significantly faster than those indoors (691 v. 586 g/day).

Table 1. Liveweights gains of weanlings fed supplementary concentrates outdoors or indoors in winter.

Environment (E)	Outdoors		Indoors				Significance		
Concentrates (C)	**None**	**2 kg/day**	**None**	**2 kg/day**	**Protein[1]**	**s.e.d[2]**	**E**	**C**	**E x C**
Silage intake (kg DM/day)	4.31	3.89	4.45	3.99	3.90	-	-	-	-
Liveweight gains (kg/day) for:									
Days 0 to 55	508	592	331	700	683	42.5	NS	***	***
Days 55 to 127	535	1061	469	810	824	44.3	***	***	*
Days 0 to127	523	858	409	762	763	33.7	**	***	NS
Days 127 to 169	696	423	1020	713	719	65.7	***	***	NS
Days 169 to 237	1334	1194	1325	1225	1142	62.7	NS	NS	NS
Days 237 to 294	746	647	605	658	642	62.9	NS	NS	NS
Days 294 to 345	894	728	863	675	716	97.0	NS	NS	NS
Days 127 to 237	1090	900	1208	1042	981	44.3	**	***	NS
Days 237 to 345	815	685	727	666	677	55.8	NS	NS	NS
Days 127 to 345	954	794	970	856	830	30.6	NS	***	NS
Days 0 to 345	795	817	764	821	805	23.0	NS	[3]	NS

[1]2 kg/day concentrates with high protein; [2]For n = 14; [3]P<0.07. There was no significant effect of protein.

The concentrate response was 226 g/day (646 v. 420 g/day) for the first 55 days, 434 g/day (936 v. 502 g/day) for the period from 55 days to end of winter and 344 g/day (810 v. 466 g/day) for the winter period as a whole. This represents a conversion ratio of concentrate DM to liveweight of about 5:1. There was no response to protein during the winter with overall gains of 762 and 763 g/day for the comparable low and high protein groups, respectively.

Liveweights are shown in Table 2. At the end of winter the outdoor animals were significantly heavier than those indoors (304 v. 293 kg). Thereafter, this weight difference decreased until by the end of the following grazing season the weights of the indoor and outdoor groups were almost identical (494 v. 493 kg). The concentrate fed animals were significantly heavier than those fed silage only at all times other than at final weighing. After 55 days the difference was 10 kg (252 v. 242 kg) and this had increased to 40 kg by the end of the winter (318 v. 278 kg). Thereafter, the difference decreased. By the middle of the grazing season (July 7), it had declined to 20 kg (425 v. 405 kg) and by the end of the grazing season it was down to 10 kg (498 v. 488 kg). When allowance is made for the fact that the concentrate supplemented animals were 4 kg lighter at the start, the total response to an input of 254 kg concentrates (217 kg DM) was 14 kg liveweight or a conversion ratio of concentrate DM of about 15.5 : 1. There was no effect of protein level on liveweight at any time.

Table 2. Liveweights of weanlings steers fed supplementary concentrates outdoors or indoors in winter.

Environment (E)	Outdoors		Indoors				Significance		
Concentrate (C)	None	2 kg/day	None	2 kg/day	Protein	s.e.d	E	C	E x C
Liveweights (kg) at:									
Start (12/11)	219	213	219	217	220	1.1	*	**	NS
Day 55 (6/1)	246	245	238	256	258	2.3	NS	***	***
Day 127 (19/3)	285	322	271	314	317	4.2	**	***	NS
Day 169 (30/4)	314	340	314	344	347	4.1	NS	***	NS
Day 237 (7/7)	405	421	404	429	425	5.1	NS	***	NS
Day 345 (23/10)	493	495	483	501	498	7.6	NS	NS	NS
Retention index (%)[1]	-	19	-	38	31				

Table 1 footnotes apply as relevant.

Discussion

During the grazing season there were no environment x winter concentrate level interactions and there was no effect of protein. Compensatory growth was evident from immediately after turnout with the groups which had the lowest gains in winter having the highest gains at pasture. Compared with being outdoors in winter, those which were indoors gained significantly faster in the 42 day period immediately after turnout and for the first half of the grazing season. Thereafter, differences were not significant and the difference for the grazing season as a whole was not significant but it did favour those which had been indoors in winter (913 v. 874 g/day). For the entire experimental period from housing to the end of the following grazing season, liveweight gains were almost identical for the outdoor and indoor groups (806 and 793 g/day, respectively). All through the grazing season the animals given no concentrates in winter gained faster than those given concentrates, significantly so for the first half of the grazing season and for the grazing season overall. Mean liveweight gains for the grazing season overall were 962 and 825 g/day for the silage only and silage plus concentrate groups, respectively. For the entire experimental period the mean response to concentrates was 39 g/day (819 v. 780 g/day, $P<0.07$).

Conclusions

- Weanlings fed outdoors gained 13 kg more over a 127-day winter than those fed similarly indoors (88 v 75 kg) but by the end of the subsequent 218-day grazing season this difference had decreased to 4 kg as a result of compensatory growth.

- Feeding 2 kg/day of supplementary concentrates in winter decreased silage intake by 0.44 kg/day DM and increased total DM intake by 1.27kg/day.
- Daily liveweight gain was increased by 344 g/day due to concentrate feeding resulting in a liveweight gain difference of 44 kg at the end of winter. By the end of the grazing season this difference had declined to 14 kg (68% compensation).
- There was no effect of concentrate protein level at any time during the experiment.
- The conversion ratio of concentrate DM to liveweight gain was 5 : 1 at the end of winter but by the end of the grazing season it was over 15 : 1.
- At a concentrate price of 19.3 c/kg DM (€165/t), the cost of 1 kg extra liveweight at the end of winter was 95 c. The corresponding cost at the end of the following grazing season was 300 c. Clearly, the response to feeding 2 kg/day of supplementary concentrates in winter to animals destined for retention on the farm to the end of the following grazing season was uneconomic.

Experiment 2

Response to Concentrate Level and Pattern of Feeding

Introduction

Generally, the level of concentrates fed to weanlings in winter is low and the question arises whether the same total allowance fed over a portion of the winter would give the same response as if fed at a flat rate over the entire winter. Reducing or eliminating concentrate feeding towards the end of winter is sometimes practised. The objectives were (1) to determine the growth response of weanlings to increasing level of supplementary concentrates, (2) to determine the effect of pattern of concentrate supplementation, and (3) to examine performance subsequently at pasture.

Experimental

Sixty spring-born Charolais x Friesian weanling steers, 9 months old and 263 kg initial liveweight, were used. They had been at pasture from the previous May until November 17 when they were blocked on weight to 5 treatment groups as follows:

1) Silage only
2) Silage + 1.5 kg concentrates per head daily
3) Silage + 3.0 concentrates kg per head daily
4) Silage + 3.0 kg concentrates for 65 days followed by silage only
5) Silage only for 65 days followed by silage + 3.0 kg concentrates per head daily.

Thirty six animals were penned in individual stalls in a tie-up shed to permit measurement of silage intake and the remainder were penned by treatment group in a slatted shed. The concentrates were fed once daily. The duration of the treatments was 122 days (November 17 to March 19) after which all the animals were put to pasture together for a 223-day grazing season.

Two second cut silages were fed. For the first to 65 days of the experiment, the silage analysis was (g/kg): DM 174, pH 3.7, CP in the DM 185, and DMD 726. The corresponding values for the silage fed from 65 to 122 days were 187, 4.1, 186 and 720. The composition of the concentrate was (g/kg) : rolled barley 870, soyabean meal 68, molasses 47 and minerals/vitamins 15. The chemical analysis of the concentrate was (g/kg) : DM 860, CP 143, ash 40, crude fibre 36. The data were analysed according to a randomized complete block design.

Over the first 65 days, the 36 individually penned animals consisted of 6 each from Treatments 1 and 5 (silage only), 12 from Treatment 2 (silage + 1.5 kg/day concentrates) and 6 each from Treatments 3 and 4 (silage + 3 kg/day concentrates). After 65 days they consisted of 6 each from Treatments 1 and 4 (silage only), 12 from Treatment 2 (silage + 1.5 kg/day concentrates) and 6 each from Treatments 3 and 5 (silage + 3 kg/day concentrates).

Results

Silage DM intakes are shown in Table 3. Silage intake decreased with increasing concentrate level. Over the first 65 days, feeding 1.5 kg/day concentrates (1.29 kg DM) reduced silage DM intake by 0.31 kg/day and accordingly increased total DM intake by 0.98 kg DM/day. After 65 days, the reduction in silage intake was only 0.18 kg DM/day so total intake was increased by 1.11 kg/day. For the period as a whole, feeding 1.5 kg concentrates per day reduced silage DM intake by 0.25 kg/day and increased total DM intake by 1.04 kg/day. Compared with feeding 1.5 kg concentrates daily, feeding 3.0 kg/day reduced silage DM intake by 0.68 kg/day in the first 65 days, 0.84 kg/day after 65 days and 0.76 kg/day overall. Corresponding increases in total DM intake were 1.90, 1.74 and 1.82 kg/day. Total concentrate intakes for the concentrate treatments (kg/day) 1.5, 3.0, 3.0 for the first 65 days, and 3.0 after 65 days, were 175, 350, 180 and 155 kg, respectively.

Table 3. Silage intake of weanlings fed silage plus supplementary concentrates.

Intakes (kg DM/day)	**Silage only**	**Silage + 1.5 kg/day**	**Silage + 3.0 kg/day**	**s.e.d[1]**	**Significance**
Days 0 -65[2]	4.57[a]	4.26[ab]	3.58[b]	0.132	***
Days 65 – 122[2]	5.03[a]	4.85[ab]	4.01[b]	0.150	***
Days 0 – 122[2]	4.78[a]	4.53[ab]	3.77	0.135	***

[1]For n = 12; [2] Means for animals fed these diets in this period. [a,b]Within a row values with a common superscript do not differ significantly in this and subsequent tables.

Liveweight gains are shown in Table 4. Over the first 65 days there was no difference between the two treatments (1 and 5) fed silage only or the two treatments (3 and 4) fed silage plus 3.0 kg/day concentrates. Compared with silage only, feeding 1.5 kg/day concentrates increased growth rate by 473 g/day and feeding a further 1.5 kg/day further increased growth rate by 167 g/day. After 65 days there was again no difference between the two treatments (1 and 4) fed silage only or between the two treatments (3 and 5) fed silage plus 3.0 kg/day concentrates. The response to the first 1.5 kg /day concentrates was 505 g/day and the additional response to the second 1.5 kg/day concentrates was 195 g/day. For the treatment period as a whole the response to 1.5 kg/day concentrates was 488 g/day and the further response to the second 1.5 kg/day concentrate increment was 195 g/day. Clearly, there was a marked decline in response with increasing level of concentrate supplementation.

Table 4. Liveweights gains of weanlings fed silage plus supplementary concentrates.

Daily gains (g) for :	**Silage Only**	**Silage + 1.5 kg/day**	**Silage + 3.0 kg/day**	**Silage + 3.0/0.0 kg/day[1]**	**Silage + 0.0/3.0 kg/day[2]**	**s.e.d.[3]**	**Significance**
Days 0-65	213^{a}	686^{b}	853^{b}	863^{b}	192^{a}	80.9	***
Days 65-122	135^{a}	640^{b}	866^{c}	156^{a}	705^{bc}	68.9	***
Days 0-122	176^{a}	664^{c}	859^{d}	533^{bc}	432^{b}	51.2	***
Days 122-164	816^{a}	641^{b}	512^{ab}	855^{a}	863^{a}	84.2	***
Days 164-232	1363	1277	1183	1354	1234	86.3	NS
Days 122-232	1154	1034	927	1164	1092	71.5	NS
Days 232-345	687	701	725	825	813	53.5	NS
Days 122-345	917^{ab}	866^{b}	824^{bc}	992^{a}	951^{ab}	41.3	**
Days 0 – 345	655^{a}	794^{b}	836^{b}	830^{b}	767^{b}	31.4	***

[1]3.0 kg/day concentrates to 65 days and none afterwards; [2]No concentrates for 65 days and 3.0 kg/day afterwards; [3]For n = 12.

Liveweights of the animals are shown in Table 5. After 65 days all the animals fed concentrates were significantly heavier than those fed silage only. By 122 days, the animals fed 3.0 kg/day concentrates were significantly heavier than all the other concentrate supplemented groups which did not differ significantly but which were all significantly heavier than the silage only group. Liveweight responses after 122 days were 60 kg to 1.5 kg/day concentrates, 83 kg to 3.0 kg/day concentrates, 43 kg to 3.0 kg/day concentrates for the first 65 days and 31 kg to 3.0 kg/day concentrates after 65 days. These represent corresponding conversion ratios of concentrate DM to liveweight gain of 2.5, 3.7, 3.6 and 4.4.

Table 5. Liveweights of weanlings fed silage plus supplementary concentrates

Liveweight (kg) at:	Silage only	Silage + 1.5 kg/day	Silage + 3.0 kg/day	Silage + 3.0/0.0 kg/day	Silage + 0.0/3.0 kg/day	s.e.d.	Significance
Start	263	263	263	262	262	6.9	NS
Day 65	277[a]	307[b]	318[b]	318[b]	275[a]	7.7	***
Day 122	284[a]	344[c]	367[d]	327[bc]	315[b]	8.1	***
Day 164	318[a]	371[bc]	389[c]	363[bc]	351[b]	8.1	***
Day 232	411[a]	457[bc]	469[c]	455[bc]	435[ab]	11.3	**
Day 345	489[a]	537[b]	551[b]	549[b]	527[b]	12.7	**
Retention index (%)[1]	-	81	75	139	124		

[1]Proportion of the weight difference at the end of winter which was still present at the end of the grazing season. (See Table 4 foot-noes also)4

The differences between the treatments in liveweight decreased throughout the grazing season but significant differences still existed at the end of the grazing season. The liveweight responses at the end of the grazing season were 48 kg to 1.5 kg/day concentrates, 62 kg to 3.0 kg/day concentrates, 60 kg to 3.0 kg/day concentrates up to 65 days and 38 kg to 3.0 kg/day concentrates after 65 days. These represent corresponding conversion ratios of concentrate DM to liveweight gain of 3.2, 4.9, 2.6 and 3.6.

Discussion

While the animals fed 3.0 kg/day concentrates after 65 days received somewhat less total concentrates than those fed 3.0 kg earlier or those fed 1.5 kg/day all through (155 v. 175 and 180 kg) they grew significantly slower. Clearly, if a fixed allowance of around 150 to180 kg concentrates is to be fed over the winter, the maximum winter response is obtained when it is fed at a flat rate. If it is being fed over one of other half of the winter period then a better response is obtained to feeding over the first than over the second half of the winter period.

Even though performance was modest in the 6 weeks period immediately after turn-out, there was nevertheless evidence of compensatory growth with those groups which had grown more slowly over the winter growing faster at pasture. This trend continued throughout the grazing season although differences in gain were generally not significant. For the grazing season as a whole, there was no significant difference between the group fed silage only and the groups fed 3.0 kg/day concentrates over one or other half of the winter period but the animals fed either 1.5 or 3.0 kg/day over the entire winter grew more slowly. For the entire period from the start of the experiment to the end of the following grazing season mean responses were 139 g/day for animals fed 1.5 kg/day concentrates over the entire winter, 181 g/day for animals fed 3.0 kg/day concentrates over the first 65 days and 112 g/day for animals fed 3.0 kg/day concentrates after 65 days. The response to the second 1.5 kg/day concentrate increment over the first increment was 42 g/day.

For reasons which are unclear there was little compensatory growth during the grazing season and in fact for some groups the weight differences were greater at the end of the grazing season than at the end of winter. Nevertheless, a number of conclusions can be drawn. The same total concentrate allowance gave a better response when fed at a flat rate over the entire winter, or at a high rate over the first half of the winter, than when fed at a high rate over the second half of the winter. The response to the second 1.5 kg/day concentrate increment was less than one third that to the first increment. At present prices of cattle and concentrates, feeding 1.5 kg/day concentrates either at a flat rate over the whole winter or at a high rate during the first half of the winter was economically justified but the unusually low rate of compensatory growth must be factored in.

Conclusions

- Silage intake decreased with increasing level of concentrate intake but total intake was considerably increased by concentrate supplementation.
- Feeding a second 1.5 kg/day concentrate increment was not economically justified when evaluated either at the end of the winter or the end of the following grazing season.
- Feeding a fixed total concentrate allowance gave a better response when offered at a flat rate daily or at a high rate over the first half of the winter than when offered at a high rate over the second half of the winter.
- Feeding 1.5 kg/day concentrates over the entire winter or 3.0 kg/day concentrates over the first half of the winter was economically justified but this was contributed to by an unusually low rate of compensatory growth during the grazing season.

FINISHING CATTLE

Experiment 1

Timing of Concentrate Feeding for Finishing Steers

Introduction

It has been shown previously that the pattern of concentrate distribution has no effect on performance or efficiency of feed utilisation in finishing steers. Thus, where animals must be retained until a specified date to comply with premia regulations, they could be fed a fixed concentrate allowance daily over the entire finishing period or they could be fed all the concentrates together towards the end of the finishing period. The latter approach would facilitate greater control over the total amount of concentrates fed and the fatness of the animals at slaughter. The objective of this experiment was to compare the response to a fixed total concentrate allowance fed at a flat rate daily or fed *ad libitum* after various periods on silage only.

Experimental

Fifty-six Charolais x Friesian steers, about 19 months of age and 568 kg mean liveweight, were blocked on weight to 8 groups of 7 animals each. Two groups were then assigned at random to each of 4 treatments as follows:

1. Concentrates *ad libitum* to slaughter after 83 days (ADLB)
2. Silage + 6.35 kg/day concentrates, slaughtered after 126 days (FLAT)
3. Silage only for 35 days, followed by concentrates *ad libitum* to slaughter after 126 days (AF35)
4. Silage only for 70 days followed by concentrates *ad libitum* to slaughter after 149 days (AF70)

The intention was to feed the same total concentrate allowance (800 kg per animal) in all treatments. Concentrates were increased gradually after introduction and silage was reduced as concentrates were increased. Animals on *ad libitum* concentrates received 1 kg/day of silage DM at all times. Silage and concentrate intakes were measured per pen (2 pens per treatment) throughout the experiment. The concentrate formulation was 870 g/kg barley, 67.5 g/kg soyabean meal, 47.5 g/kg molasses and 15 g/kg mineral/vitamin premix. Initially the concentrate was ground and pelleted but it was changed to a coarse mix after 4 weeks. The animals were slaughtered in a commercial abattoir at the end of their treatment period and routine slaughter data were collected.

Results

Mean silage analysis (g/kg) was : DM 171, crude protein in the DM 164, *in vitro* DM digestibility 711, and pH 3.73. Silage DM and concentrate intakes by period and for the experiment overall are shown in Table 6. Mean total silage DM intakes for Treatments 1, 2, 3 and 4 were 133, 486, 449 and 591 kg, respectively. Corresponding concentrate intakes were 815, 788, 798 and 817 kg. The reasons for the small differences between treatments in concentrate intake were the variations in *ad libitum* intake between groups and the fact that animals could not always be slaughtered on the target date. As the maximum difference in concentrate intake between groups was only 29 kg (3.6% mean intake), for practical purposes it can be taken that concentrate intake was similar for all treatments. With similar concentrate intakes and the same duration of finishing for Treatments 2 and 3, similar silage intakes might also be expected for these two groups. However, silage intake was 37 kg DM (8% of mean silage intake for these two groups) higher for Treatment 2. Total DM intakes (concentrate DM = 840 g/kg) for Treatments 1, 2, 3 and 4 were 818, 1148, 1119 and 1277 kg, respectively. Corresponding concentrate proportions in the DM were 0.837, 0.577, 0.599 and 0.587.

Table 6. Mean silage (kg DM) and concentrate (kg)[1] intakes of steers offered different concentrate distribution patterns.

Days		**ADLB**	**FLAT**	**AF35**	**AF70**
1-33	Silage	2.50	3.90	5.85	5.83
	Concentrate	7.09	5.07	-	-
34-82[2]	Silage	1.00	4.17	4.20	5.71
	Concentrate	11.63	6.00	5.31	0.90
83-131[3]	Silage	-	3.47	1.14	2.06
	Concentrate	-	7.42	12.22	10.90
132-149	Silage	-	-	-	1.00
	Concentrate	-	-	-	13.26
Total	**Silage**	**133**	**486**	**449**	**591**
	Concentrate	**815**	**788**	**798**	**817**

[1]Fresh; [2]Day 83 for ADLB ; [3]Day 126 for FLAT and AF35

Liveweights, liveweight gains and estimated carcass weight gains are shown in Table 7. Liveweight gains during the first 5 weeks were lower than expected for all treatments. During this period the animals on the ADLB and FLAT treatments were allowed to gradually accustom themselves to their target concentrate levels while the animals on the AF35 and AF70 treatments were still on silage only. As this was only sufficient for maintenance because of low intake, the response to concentrates in ADLB and FLAT was as expected. In the period 35 to 70 days, performance on silage only (AF70) improved but the response to concentrates in the other treatments was poor. From 49 days to slaughter, the ADLB animals gained 1224 g/day.

Table 7. Liveweight and carcass weight gains (g/day) of steers offered different concentrate distribution patterns.

Days	ADLB	FLAT	AF35	AF70	s.e.d.	Significance
0-35	863[a]	623[a]	157[b]	29[b]	84.1	***
35-70	883[a]	780[a]	571[ab]	400[b]	72.6	***
0-70	873[a]	701[a]	364[b]	214[b]	61.6	***
49-83[1]	1224	-	-	-	-	-
35[2]-126[3]	-	752[a]	1040[b]	1029[b]	59.8	***
70[4]-149[5]	-	-	-	1282	-	_
0-slaughter	991[a]	715[b]	794[b]	780[b]	56.4	**
Carcass gain[6]	689[a]	523[b]	601[ab]	562[b]	37.6	*

[1]Slaughter day for ADLB; [2]Start of concentrate feeding for AF35; [3]Slaughter day for FLAT and AF35; [4]Start of concentrate feeding for AF70; [5]Slaughter day for AF70 ; [6]Assuming initial carcass weight = initial liveweight x 0.51

For the first 10 weeks (0 to 70 days), the animals on silage only (AF70) gained only 214 g/day while those on silage + 6 kg/day concentrates gained 701 g/day, i.e. a response of 81 g liveweight per kg concentrates. While this concentrate response was in the normal range, overall performance was low largely because of the poor performance on silage. After 70 days, animals on *ad libitum* concentrates gained 1282 g/day (AF70), while those on silage + concentrates (FLAT) gained only about 700 g/day. There was no significant difference between FLAT, AF35 and AF70 in overall liveweight or carcass weight gains for the entire finishing period but ADLB animals had significantly higher liveweight and carcass weight gains than the other three treatments.

Liveweights, liveweight and carcass weight gains, and body condition scores are shown in Table 8. Because of the different feeding treatments, liveweights differed significantly between treatments at all times other than on day 126. At slaughter, the only groups to differ significantly in liveweight were ADLB and AF70 with the latter 33 kg heavier.

Table 8. Liveweights, gains and body condition scores of steers offered different concentrate distribution patterns.

Liveweight (kg) at :	**ADLB**	**FLAT**	**AF35**	**AF70**	**s.e.d.**	**Significance**
Start	568	568	566	568	9.5	NS
Day 21	589^{a}	581^{ab}	570^{b}	571^{b}	9.6	*
Day 49	608^{a}	599^{a}	572^{b}	568^{b}	9.8	*
Day 70	629^{a}	618^{a}	591^{b}	583^{b}	10.8	*
Day 126	-	659	666	663	10.4	NS
Slaughter	651^{a}	659^{ab}	666^{ab}	684^{b}	10.7	*
Body condition score[1] at :						
Day 49	3.5^{a}	3.2^{ab}	2.7^{b}	2.6^{b}	0.14	***
Slaughter	4.4	4.1	4.1	4.5	0.11	NS
Total gain of :						
Liveweight	82^{a}	90^{ab}	100^{bc}	116^{c}	6.6	**
Carcass weight[2]	57^{ab}	66^{bc}	76^{cd}	84^{d}	4.4	***

[1]Scale 1 (thin) to 5 (fat); [2]Assuming initial carcass weight = initial liveweight x 0.51

Body condition scores were not recorded at the start but were probably similar to those for AF35 and AF70 at day 49 (i.e. 2.6-2.7). Condition score therefore increased rapidly over the first 7 weeks particularly for the ADLB group. At slaughter there was no difference in body condition score between the treatments. Thus, even though time of slaughter differed by over two months all groups appeared equally finished. Total liveweight and carcass weight gains differed significantly between treatments. They were lowest for ADLB and highest for AF70.

Slaughter data are shown in Table 9. Carcass weight followed the same trend as slaughter weight with AF70 significantly heavier than ADLB. Kill-out proportion did not differ significantly between treatments and neither did carcass conformation score. Carcass fat score was significantly lower for ADLB than for both AF35 and AF70 but this was not reflected in weight or proportion of kidney plus channel fat.

Table 9. Slaughter data for steers offered different concentrate distribution patterns.

	ADLB	**FLAT**	**AF35**	**AF70**	**s.e.d.**	**Significance**
Carcass weight (kg)	347^{a}	356^{ab}	364^{ab}	373^{b}	7.2	*
Kill-out (g/kg)	533	540	547	546	4.3	NS
Conformation[1]	2.71	2.57	2.93	2.86	0.130	NS
Fat score[2]	3.91^{a}	4.14^{ab}	4.23^{b}	4.31^{b}	0.086	*
Kidney + channel fat (kg)	11.5	11.9	11.1	13.5	0.77	NS
Kidney + channel fat (g/kg)[3]	33.0	34.0	30.5	35.9	2.10	NS
Number of teeth	0.79	1.57	1.57	2.07	0.197	***

[1]Scale 1 (poorest) to 5(best); [2]Scale 1 (leanest) to 5(fatness); [3]Of carcass weight

Slaughter coincided with time of eruption of the first pair of permanent teeth. At slaughter of the ADLB group, only about 40% of the animals had permanent teeth. By 43 days later when FLAT and AF35 were slaughtered almost 80% of the animals had two permanent teeth, and after a further 23 days when the AF70 animals were slaughtered, all animals had two permanent teeth and one animal had started to erupt the second pair of permanent teeth.

Efficiency of feed energy utilization is shown in Table 10. Total feed DM and energy intakes increased with increasing length of finishing but as liveweight and carcass weight gains also increased, efficiency of energy utilisation was similar for all treatments except FLAT which was about 15% poorer.

Table 10. Efficiency of feed energy utilisation by steers offered different concentrate distribution patterns.

	ADLB	FLAT	AF35	AF70
DM intakes (kg)				
Silage	133	486	449	591
Concentrate	685	662	670	686
Total	818	1148	1119	1277
ME intakes (MJ)				
Silage[1]	1370	5006	4625	6087
Concentrates[2]	8563	8275	8375	8575
Total	9933	13281	13000	14662
Efficiency (MJ/kg)				
Liveweight	121	147	130	126
Carcass	174	202	172	175

[1](*in vitro* DMD - 61) * 0.011 + 3.2 = 10.3 MJ/kg for silage ;

[2]Barley = 12.7, soyabean meal = 13.4, molasses = 12.5 MJ/kg DM. For (g/kg) 870 barley, 67.5 soya, 47.5 molasses and 15 mineral/vitamin premix = 12.5 MJ/kg DM

Discussion

Although silage digestibility was quite high intake was very low. For the first 35 days for AF35, and the first 70 days for AF70, until concentrates were introduced, silage intake was less than 6 kg DM/day or the equivalent to about 10 g/kg bodyweight. There is no obvious explanation for this low intake other than perhaps the relatively low silage pH (3.73) and low DM concentration (171 g/kg).

For the first 5 weeks of the experiment, mean concentrate intake of ADLB was only around 7 kg/day. This was due to the fact that it proved impossible to reach *ad libitum* intake because of recurring digestive upsets on the ground/pelleted ration used initially. When this was replaced by a coarse mix intake increased to normal levels. The delay in reaching *ad libitum* intake and the recurring digestive upsets explain the relatively low performance of both ADLB and FLAT in the early weeks of the study. When these problems were overcome performance thereafter on ADLB exceeded 1.2 kg/day. Intakes and performance of AF35 and AF70 when they were on *ad libitum* concentrates tended to be higher than those for ADLB but this would be expected as the animals were older and heavier and had an extra period of rumen development before going on to *ad libitum* feed. The consistently low performance throughout of the FLAT group was surprising considering that the mean level of concentrate intake exceeded 6 kg/day. The main reason was low silage intake. With the mean concentrate intake of 5.25 kg DM/day, mean silage intake was only 3.86 kg DM/day giving a total DM intake of 9.11 kg/day. This is equivalent to only 14.9 g/kg bodyweight.

Total liveweight and carcass weight gains increased with length of finishing period. There were no effects on kill-out or on carcass conformation but fat score increased . This might be expected because of the increased weight, but it was not reflected in either kidney plus channel fat weight or proportion. Thus, there was no evidence of the difference in fatness between the silage plus concentrates and the concentrates *ad libitum* fed animals observed previously. Slaughter coincided with time of first permanent teeth eruption and in a period of 66 days the proportion of animals with their first permanent teeth went from <40 % to 100 %.

Surprisingly, efficiency of feed energy utilisation did not decrease with increasing length of finishing period and there was no difference in feed energy utilisation between the 3 groups finished on *ad libitum* concentrates. These however, were 15% more efficient than the group fed concentrates at the flat rate.

Conclusions

- The maximum potential growth rate of Charolais x Friesian steers, 19 months of age and 570 kg liveweight, is in the range 1.2 to 1.4 kg/day. This growth rate was achieved on an all concentrate diet offered either immediately after housing or following a period indoors on silage only.
- For reasons which are unclear intake and performance were low on silage of good digestibility.
- Feeding a fixed total concentrate allowance *ad libitum* over the final part of the finishing period was superior to feeding it at a flat rate per day over the total period particularly in terms of feed energy utilisation.
- There was no impairment in efficiency by delaying concentrate feeding for 35 or 70 days compared with starting immediately after housing.

Experiment 2

Response in Finishing Steers to Supplementary Concentrates Fed after Different Periods on Silage

Introduction

There is enormous variation in the performance of finishing cattle fed apparently similar diets and responses to concentrate supplementation vary greatly between experiments. Differences in performance and response to concentrates could be due to expression of different levels of compensatory growth but the literature is equivocal on whether or not compensatory growth occurs in cattle fed indoors in winter.

The objective of this experiment was to determine the response in finishing steers to a fixed allowance of supplementary concentrates fed after the animals had spent varying intervals on silage only. Such animals should then have varying levels of compensatory growth potential.

Experimental

Seventy two finishing steers (48 Charolais x Friesians and 24 Friesians) were blocked on weight within breed type and assigned from within blocks to four finishing treatments. Within finishing treatment and breed type the animals were assigned at random to three pens of 6 animals each (4 Charolais x Friesians + 2 Friesians per pen). These were considered replicates for the purposes of feed intake measurements. All animals were offered grass silage *ad libitum* following allocation to treatment.
The four treatments were :

1. Silage + 6 kg/day concentrates for 150 days (FLAT)
2. Concentrates *ad libitum* commencing on day 0 (ADLB)
3. Concentrates *ad libitum* commencing on day 56 (AF56)
4. Concentrates *ad libitum* commencing on day 112 (A112)

The intention was that all groups would receive the same total concentrate allowance (900 kg) during finishing and that all groups would be slaughtered immediately they had consumed their concentrate allowance. Body condition score was recorded on days 0 and 56 and at slaughter. The silage analysis was : DM 200 g/kg, CP in the DM 157 g/kg, DMD 716 g/kg, and pH 3.9. The concentrate formulation was as for Experiment 1 and it was fed as a coarse mix.

Results

Because it took some time for the cattle on FLAT to reach their 6 kg/day concentrate intake allowance, mean concentrate intake over the first 8 weeks averaged only 4.67 kg/day (Table 11). In the period 9 to 12 weeks the intended level of 6 kg/day was consumed. Later to compensate for the lower intake earlier, and when it became apparent the ADLB group would exceed the target allowance, the concentrate level for FLAT was increased to 7 kg/day. Mean concentrate intake for the total finishing period was 5.8 kg/day. A digestive upset in the early weeks delayed the ADLB animals reaching *ad libitum* intake and their mean intake for the first 8 weeks was only 6.5 kg/day. In the period 9 to 12 weeks their concentrate intake exceeded 11 kg/day. The low intake shown for the period 13 to 21 weeks simply reflects the fact that the animals were slaughtered after 15 weeks. Total concentrate intakes for FLAT and ADLB were 892 and 936 kg, respectively. The animals on AF56 reached *ad libitum* concentrate intake in about 4 weeks following introduction and peak intake exceeded 12 kg/day. Total intake was 937 kg. The animals in A112 also reached *ad libitum* intake quickly following introduction and peak intake exceeded 13 kg/day. Total concentrate intake was 925 kg.

Daily silage intakes showed the opposite trend to concentrate intakes. Total silage DM intakes were 918, 321, 688 and 1157 kg for FLAT, ADLB, AF56 and A112 , respectively. Total DM intakes increased with length on feed and mean values were 1662, 1103, 1471 and 1930 kg for the treatments as listed.

Table 11. Silage and concentrate intakes (kg/day)[1] of steers fed concentrates following different periods on silage only.

	Weeks	FLAT	ADLB	AF56	A112	s.e.d.	Significance
Silage	1 to 8	6.12[a]	4.22[b]	7.60[c]	7.72[c]	0.061	***
	9 to 12	5.51[a]	1.71[b]	4.86[c]	8.82[d]	0.089	***
	13 to 21	6.00[a]	0.59[b]	2.00[c]	6.36[d]	0.069	***
	22 to 28	0.88[a]	-	-	1.57[b]	0.016	***
	Total (kg)	918[a]	321[b]	688[c]	1157[c]	17.5	***
Concentrates	1 to 8	4.67[a]	6.45[b]	-	-	0.063	***
	9 to 12	6.00[a]	11.24[b]	6.43[a]	-	0.259	***
	13 to 21	6.56[a]	4.14[b]	12.01[c]	4.61[d]	0.138	***
	22 to 28	1.00[a]	-	-	13.01[b]	0.084	***
	Total (kg)	892	936	937	925	15.3	NS
Total	1 to 8	10.02[a]	9.60[ac]	7.60[b]	7.72[bc]	0.080	***
	9 to 12	10.52[ab]	11.09[a]	10.23[b]	8.82[c]	0.237	***
	13 to 21	11.48[a]	4.05[b]	12.05[c]	10.20[d]	0.137	***
	22 to 28	1.72[a]	-	-	12.43[b]	0.070	***
	Total (kg)	1662[a]	1103[b]	1471[c]	1930[d]	18.0	***
	Metabolisable energy (MJ)[2]	18341	12823	16503	21070		

[1]Silage and total intakes are in dry matter (DM), concentrate intake is fresh (835 g/kg DM).
[2]Assuming values of 10.0 and 12.3 MJ/kg DM for silage and concentrates, respectively.

Liveweights and liveweight gains are shown in Table 12. Mean initial liveweight was 483 kg. The animals fed the flat rate of concentrates (FLAT) had livewight gains of close to 1 kg/day (983 g/day). The ADLB animals gained 1240 g/day overall. The AF56 animals which spent 56 days on silage averaged 964 g/day overall, while the A112 animals averaged 945 g/day overall. Of particular interest is the gain of the animals from the start of concentrate feeding to slaughter. For FLAT, the overall gain and that from the start of concentrate feeding were the same thing. Similarly for ADLB, as concentrate feeding commenced at the start of the experiment and continued to slaughter. For AF56, overall gain was 964 g/day while gain from the start of concentrate feeding was 1119 g/day. This was lower than the 1240 g/day for ADLB so there was no evidence of any expression of compensatory growth following the 56 day period on silage only.

Table 12. Liveweight gain and liveweights of steers fed concentrates following different periods on silage only.

	FLAT	ADLB	AF56	A112	s.e.d.	Significance
Liveweights (kg)						
Day 0	483	483	483	483	3.3	NS
Day 56	531^{a}	544^{b}	509^{c}	513^{c}	3.7	***
Day 104[1]	589^{a}	612^{b}	589^{a}	541^{c}	6.2	***
Slaugher	634^{a}	612^{b}	623^{ab}	668^{c}	5.2	***
Days to slaughter	154	104	146	196	-	-
Liveweight gains (g/kg)						
Days 0 to 42	1034^{a}	1339^{b}	538^{c}	607^{c}	59.4	***
Days 42 to 98	959^{a}	1211^{b}	1344^{b}	443^{c}	56.6	***
Days 0 to 98	991^{a}	1266^{b}	999^{a}	513^{c}	43.4	***
Days 0 to slaughter	983^{a}	1240^{b}	964^{a}	945^{a}	32.6	***
Ad libitum concentrates[2]	-	1240	1119	1483	-	-
Body condition score[3]						
Day 0	2.58^{a}	2.78^{b}	2.56^{a}	2.50^{a}	0.092	*
Day 56	3.19^{a}	3.25^{a}	2.69^{b}	2.50^{b}	0.103	***
Slaughter	4.28	4.22	4.17	4.33	0.143	NS

[1]Nearest weight to day 112 ; [2]Period when animals were on concentrates *ad libitum* ; [3]Scale 1 (thin) to 5 (fat).

The animals in A112 gained 1483 g/day from the time they commenced concentrate feeding. As this is considerably higher than the ADLB and AF56 values it does indicate a contribution of over 200 g/day from compensatory growth. The A112 animals consumed their concentrate allowance in 84 days compared with 90 and 104 days for AF56 and ADLB, respectively.

At the start of the experiment, body condition score was unintentionally higher for ADLB than for the other treatments. By 56 days there were considerable differences in body condition score reflecting level of feeding and growth rate up to then. At slaughter however, there was no significant difference in body condition score between the treatments.

Slaughter traits are shown in Table 13. There was a significant difference between treatments in carcass weight, which was lowest for ADLB and highest for A112. Kill-out was significantly lower for FLAT probably because of higher gut fill. Conformation was better for AF56 and A112 than for FLAT and ADLB, probably because of the greater carcass weight. Carcass fat score was lowest for FLAT and highest for ADLB and A112. However, weight and proportion of kidney plus channel fat was in the opposite direction being highest for FLAT. This agrees with previous findings. The differences in fat and conformation scores may reflect variation in grading because the animals were slaughtered on different days. There was no liver damage in FLAT but some animals in all the groups fed concentrates *ad libitum* had minor liver damage. Carcass gain was lowest for ADLB and highest for A112. Efficiency of metabolisable energy (ME) utilisation was highest for ADLB and poorest for FLAT.

Table 13. Slaughter traits steers fed concentrates following different periods on silage only.

	FLAT	ADLB	AF 56	A112	s.e.d.	Significance
Carcass weight (kg)	328.4[a]	322.6[a]	330.0[a]	352.6[b]	3.45	***
Kill-out (g/kg)	518[a]	527[b]	529[b]	527[b]	2.6	*
Conformation	2.17[a]	2.33[a]	2.58[b]	2.50[b]	0.088	*
Fat score	3.70[a]	4.13[b]	4.05[b]	4.13[b]	0.092	**
Kidney + channel fat (kg)	15.9[a]	11.9[b]	12.5[b]	14.7[a]	0.52	***
Kidney + channel fat (g/kg)	48.7[a]	37.1[b]	38.0[b]	42.2[c]	1.64	***
No. teeth	1.92	1.54	1.79	2.04	0.128	NS
Liver damage score[1]	1.00	1.21	1.29	1.17	0.08	NS
Initial carcass weight (kg)[2]	233.2	233.1	233.1	233.1		
Carcass gain (kg)	95.2	89.5	96.9	119.5		
Carcass gain (g/day)	618	861	664	610		
Efficiency (MJ ME/kg carcass)	193	143	170	176		

[1]Scale 1 (normal) to 3 (severe damage) ; semi colour ; [2]Assuming initial kill-out proportions of 470 g/kg for Friesians and 490 g/kg for Charolais x Friesians. See Table 9 footnotes

Discussion

An objective of the study was to ascertain whether the variation in finishing cattle performance might be due to differences in compensatory growth potential as a result of differences in previous nutrition and body condition score at the start of finishing. The outcome is not clear because there was no evidence of compensatory growth following a delay of 56 days but there was considerable compensatory growth following a delay of 112 days. If the results of AF56 are considered an aberration (for which there is no obvious explanation) then the comparison of ADLB and A112 shows that delaying the introduction of concentrates for 112 days increased concentrate intake by over 1 kg/day and increased liveweight gain by 243 g/day. This indicates that for every one week delay in introducing concentrates, liveweight gain subsequently was increased by about 15 g/day. Carcass fat score as lowest for FLAT and similar for the other three treatments. This is in conflict with earlier results showing that animals finished on silage plus a flat rate of supplementary concentrates were fatter than those finished on concentrates *ad libitum.* However, the more objective indicator of fatness, namely kidney plus channel fat proportion, indicates the opposite and supports previous findings that carcasses finished on silage plus a flat rate of concentrates are fatter than those finished on concentrates *ad libitum.* In agreement with Experiment 1, the flat rate feeding of concentrates resulted in poorest efficiency of energy utilisation.

Conclusions

- Where animals are being finished over about a 5-6 month period it is better to delay the introduction of concentrate feeding for up to three months and then feed the concentrates *ad libitum* thereafter. Total carcass gain is about the same as for flat rate feeding but silage consumption is lower and efficiency is improved.
- During *ad libitum* concentrate feeding, animals previously on silage only for 16 weeks, gained 364 g and 243 g/day, respectively more liveweight than animals given concentrates after 8 weeks or from the beginning. This indicates that for every week concentrate feeding is delayed, daily gain is increased by about 15 g when the animals are subsequently finished on *ad libitum* concentrates.

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